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## **TITLE**

‘Owner-reported lower urinary tract signs in a cohort of young cats’

## **ABSTRACT**

### **Objectives**

The most common cause of lower urinary tract signs (LUTS) in cats under the age of 10 years is feline idiopathic cystitis (FIC). The prevalence of LUTS in the UK pet cat population is difficult to assess. This study used data collected prospectively to investigate the prevalence of, and risk factors for, owner-reported LUTS in a cohort of young pet cats.

### **Methods**

Cat owners were recruited onto a long-term longitudinal study and asked to complete questionnaires at specified age-points for their cats. All cats were at least 18 m at the time of analysis. The prevalence of owner-reported LUTS at 18, 30 and 48 months of age was calculated, based on whether the owner had seen the cat urinating, and whether the cat had displayed one or more of the following clinical signs; dysuria, haematuria or vocalising during urination. A case-control study to investigate the risk

factors for owner-reported LUTS in study cats at age 18 m was also conducted, using a multivariable logistic regression model.

## **Results**

The prevalence of owner-reported LUTS in cats seen urinating by the owner was 4.3%, 3.8% and 6.0%, with 95% confidence intervals of 3.2-5.7%, 2.5-5.7% and 3.4-10.5% at ages 18, 30 and 48 months respectively.

An indoor-only lifestyle at age 18 m and a change in diet between the ages of 12 and 18 m were identified as risk factors for owner-reported LUTS at age 18 m from the multivariable model. No clear type of change in diet was identified in our sample of cats with LUTS.

## **Conclusions and relevance**

The prevalence of owner-reported LUTS in a cohort of young pet cats was higher than the previously reported prevalence of LUTS in cats presenting to veterinary hospitals for LUTS or other reasons. A novel risk factor of change in diet between 12 and 18 m of age warrants further investigation.

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## **Abstract**

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## Introduction

Lower urinary tract signs (LUTS) in cats include stranguria, periuria, haematuria, dysuria and pollakiuria <sup>1, 2</sup>.

The prevalence of LUTS in the pet cat population in the UK is difficult to assess, the most recent estimates for the prevalence in the general population in both the UK and USA were 0.6%, but these were based on data from the mid-70s <sup>10</sup>. In 1999, Lund et al <sup>11</sup> reported LUTS in 3% (1.5% 'feline urological syndrome' and 1.5% 'cystitis') of cats examined at private veterinary practices in the United States. More recently, the Banfield State of Pet Health™ <sup>12</sup> reported that 'cystitis' (LUTS) accounted for approximately 5% of diagnoses in cats older than three years of age presented for care of a health problem.

The most common cause of LUTS in cats under the age of 10 years is FIC. Studies over the past 25 years have found that the majority, 55-73%, of cats presented to referral hospitals in USA and Europe for LUTS had FIC <sup>13-21</sup>. To the authors' knowledge, the majority of studies of the prevalence of FIC have been based on data collected from cats that have presented to a veterinary surgeon (either primary care or referral hospital) because of LUTS. There are no data on the length of time that LUTS signs were present



in the cats before the first presentation to the veterinarian. FIC can resolve without medical treatment or intervention, so LUTS may resolve in some cats before they would be presented to a veterinarian for treatment. Therefore the actual prevalence of LUTS in cats could be higher than is currently reported. LUTS can occur at any age, but are seen most commonly in middle-aged cats<sup>1, 22</sup>. The age of onset of LUTS in cats could be younger than is currently reported. Cats could show signs at an earlier age, but owners might only take the cat to a veterinarian once the signs increase in frequency, or become severe or inconvenient (e.g., periuria).

Factors previously associated with an increased risk of developing FIC include age (young adult cats at higher risk), being neutered, low activity levels, higher body condition score (BCS), limited outdoor access, stress factors such as moving house within the last three months, presence of more than one cat in the house, being in conflict with another cat in the house, and a predominantly 'dry' diet<sup>1, 4, 8, 23</sup>. Moreover, all of the information published to date on LUTS in cats was based on data obtained retrospectively to the authors' knowledge. Retrospective data collection has the potential for bias associated with recall and case-control status.

The aims of this study were to use prospectively collected data to investigate the prevalence of, and risk factors for, owner-reported LUTS in a cohort of young pet cats. We used three owner-reported LUTS (straining and vocalising when passing urine, and haematuria) to create a binary outcome of 'LUTS' to estimate the prevalence of LUTS in cats at 18, 30 and 48 m of age. Risk factors for LUTS at 18 m were also investigated.

## **Materials and Methods**

### **Data collection**

Cat owners were recruited onto a long-term longitudinal study (The Bristol Cats Study) using a variety of advertising methods including posters in veterinary practices, advertisements through websites used by cat owners, animal welfare organisations, and publications aimed at veterinarians and cat owners. Cats included in this study were recruited between 1<sup>st</sup> May 2010 and 31<sup>st</sup> December 2013. Owners were asked to complete questionnaires either online or using a paper format when their cats were approximately 3 m (2–4) (questionnaire 1 (3 m)), 7 m (questionnaire 2 (7 m)), 12 m (questionnaire 3 (12 m)), 18 (questionnaire 4 (18 m)), 30 m (questionnaire 5 (30 m)) and 48 m of age (questionnaire 6 (48 m)). Most questions were 'closed questions' with a multiple-choice format, and questionnaires took approximately 10–15 minutes to

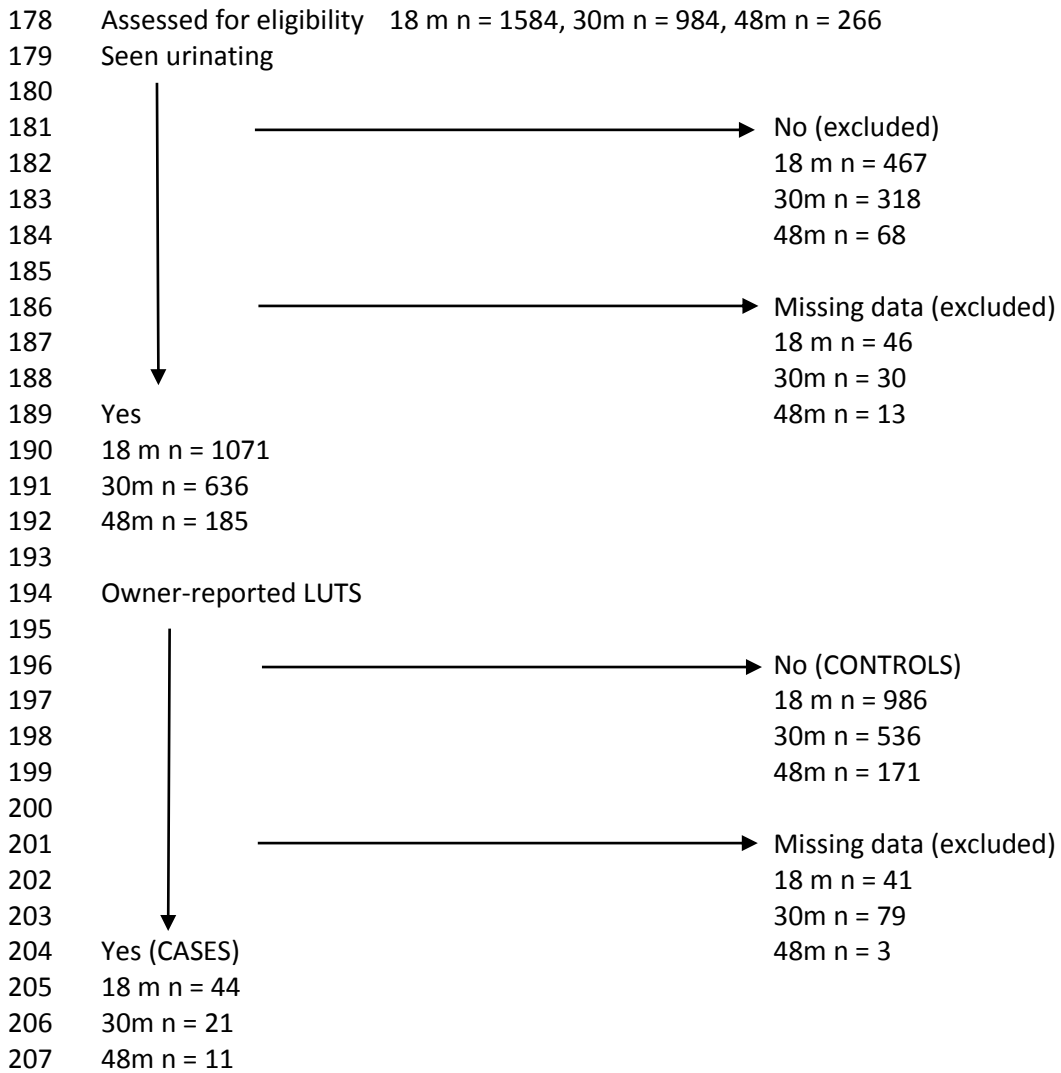
complete<sup>24</sup>. Questionnaires were developed by researchers with specialisms in feline medicine, veterinary epidemiology and feline behaviour and data from respondents were anonymised prior to analysis. Links to electronic versions of questionnaires 1-4, which were used for this study, are available at: <https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-1-kitten-aged-8-16-wks-2> (Q1), <https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-2-6-month-old-cats-c> (Q2), <https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-3-12-month-old-cats-c> (Q3) and <https://smvsfa.onlinesurveys.ac.uk/q4bc> (Q4). Salient data (data considered by the authors as appropriate to assess for association with LUTS) relating to variables (table 1) were extracted from each questionnaire.

All cats in the cohort were at least 18 m at the time of analysis. The cut-off date for inclusion of cats into the 30m and 48 m analysis was 1<sup>st</sup> June 2015; data from questionnaires received after this date were not included.

#### Descriptive statistics

The prevalence and 95% confidence intervals (95% CI) of owner-reported LUTS at 18, 30 and 48 m of age were calculated based on the data summarised in Figure 1.

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209 Figure 1. Flow chart detailing how the final numbers of cases and controls for the descriptive  
210 statistics of owner-reported LUTS among cats enrolled on the 'Bristol Cats Study' at 18, 30 and  
211 48 m were determined.

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*Case (LUTS) and control (No LUTS) definitions.*

Cases were defined as those cats whose owners had answered 'yes' to seeing the cat urinating and also answered 'yes' to at least one of the following 'LUTS questions' 'Which, if any of the following have you been aware of whilst watching your cat urinating? 'He/she strains or appears to have difficulty urinating' 'He/she has passed blood when urinating' 'He/she vocalises (e.g., miaows) before or during urination'.

Control cats were defined as those cats whose owners had answered 'yes' to seeing the cat urinating and had answered 'no' to all of the 'LUTS questions' outlined above.

We chose to include only those cats whose owners had seen them urinating for case and control selection to reduce misclassification. For example, blood could be observed in the litter tray, but unless the owner had seen the cat passing urine to know that it had come from haematuria, one could not exclude that the blood had come from another source such as a wound or haematochezia (although this is rare). Owners are more likely to notice cases rather than controls. For example, if the cat vocalises during urination the owner is more likely to notice the problem. This may overestimate the prevalence, as cats not seen urinating were excluded. It is likely those cats not seen were less likely to have LUTS in the first place. To take this into account, the prevalence (and 95% confidence intervals) were calculated using data that included those cats which the

owner had not seen urinating to provide the lowest prevalence estimate for owner-reported LUTS with the assumption that all cats not seen urinating did not have LUTS.

**Risk factors analysis of variables associated with LUTS at 18 m**

A case-control study to investigate risk factors for owner-reported LUTS in study cats at age 18 m was conducted. Cats with LUTS and cats without LUTS were identified from the dataset using the criteria outlined above. Cats were excluded from the risk factor analysis if the owner had not seen the cat urinating, if they answered 'don't know' for all three owner-reported signs, or a mixture of 'no' and 'don't know' for the three owner-reported signs (on the basis that a 'don't know' answer could not be defined as 'no' or 'yes').

Potential risk factors (summarised in Table 1) were tested for their association with LUTS at 18 m using univariable logistic regression models. Where appropriate, the number of categories of each variable was reduced by combining categories. BCS was dichotomised into 1-3 and 4-5, as the area of interest was a high BCS. Similarly with the diet, 100% dry, mostly dry, 50:50, true mix and fresh food were grouped together, since the univariable analysis did not suggest a link between dry diet (100% dry or mostly dry) and risk of LUTS.

253 Table 1. Variables assessed as potential risk factors for owner-reported LUTS in cats aged 1.5  
 254 years enrolled in The Bristol Cats Study.

Variable (Age of cat)	Description	Categories
Sex	Sex of cat reported by owner	Male Female
Breed	Breed	DSH/DLH Pedigree
Diet (12 m and 18 m)	Owners asked to state which food type(s) they fed their cat and in what proportions	100% Wet Mostly wet 100% Dry Mostly dry 50:50 Mix (wet, dry, fresh) Fresh (100% and mostly)
Change in diet between 12 m and 18 m	Did the diet category change between 12 m and 18 m old	No Yes
Multi or single cat household (12 m and 18 m)	This variable was derived from questions the owner was asked about how many cats had joined or left the household.	Multi cat Single cat
Change in 'multi/single' cat household status between 12 m and 18 m	Did the household change from single- to multi-cat or multi- to single-cat between 12 m and 18 m old.	Yes No
Age of neutering	Age of neutering as stated by owner	≤4 months 5-6 m ≥7 months Entire at 18 m
Number of cats in neighbourhood 12 m and 18 m	Number of cats reported by the owner to be in the	None 1-5 6-10



	neighbourhood at 12 m and 18 m	11 or more
Visiting cats (12 m and 18 m)	This variable was derived from three separate questions the owner was asked - if any of the cats in the neighbourhood either 1. Come into their house, 2. Come into their garden or 3. Stare through cat flaps, doors or windows	Yes No Don't know
Reaction to the 'visiting' cats <sup>1</sup> (12 m and 18 m)	Owners were asked how their cat reacted if the cat saw any of the visiting cats in their house or garden	Positive Negative No reaction Mixed reaction
Indoor and outdoor lifestyle (12 m and 18 m)	Owners were asked what the outdoor access of their cat was	Indoor only Indoors but outside on a lead or in a run Outdoors and indoors Outdoors only
Change in indoor and outdoor lifestyle between 12 m and 18 m	Did the indoor and outdoor lifestyle category change between 12 m and 18 m	Yes No
Moved house (18 m)	Had the owner moved house in the past 1 year	Yes No
Body condition score (18 m)	Owner-reported body condition score	1 (very thin) 2 (thin) 3 (ideal) 4 (overweight) 5 (obese)
Interaction with other cats in household <sup>2</sup> (18 m)	If the household was a multi-cat household, owners were asked to report how their cat interacted with other cats in the household.	Positive reaction Negative reaction Indifferent/no reaction Mixed reaction
Been in fight past 6 m (18 m)	Owners were asked to report if their cat had been	Yes No

	in a fight with another cat in the past six months	
Age of questionnaire completion (18 m-48 m)	The age of the cat as reported by the owner at the completion of Q4 (18 m), Q5 (30m) and Q6 (48m)	Age in months

<sup>1</sup>The categories in this variable were derived from the answers provided by the owner; a positive response was defined if the cat only reacted in a positive way ('rubs against them', 'licks or grooms them', 'plays with them', 'skirts around them'), a negative response if the cat reacted only in a negative way ('hisses or spits', 'chases them', 'swipes his/her paw', 'runs away'), no reaction if the cat only reacted in an indifferent way ('ignores them', 'stays still') and a mixed response if they had a positive and /or negative and/ or no reaction.

<sup>2</sup>The categories in this variable were derived from the answers provided by the owner; a positive response was defined if the cat only reacted in a positive way ('shares a sleeping place with another cat', 'grooms another cat', 'is groomed by another cat', 'rubs on another cat', 'is rubbed on by another cat', 'plays with another cat'), a negative response if the cat reacted only in a negative way ('chases another cat', 'is chased by another cat', 'hisses or spits at another cat', 'is hissed or spat at by another cat', 'is reluctant to pass another cat in a narrow space e.g. doorway', 'blocks or inhibits the movement of another cat'), an indifferent/no reaction if the cat only reacted in an indifferent way ('sleeps in the same room as another cat, but not close together') and a mixed response if they had a positive and /or negative and/ or indifferent/no reaction.

For the variables of interaction with other cats in the household at 18 m and change in household type (single/multi-cat household between 12 m and 18 m) there were no cases in one of the categories. To enable the univariable models to run, a control cat was selected at random for each model and altered to become a case and the model was run. The data were analysed in their original format for all other univariable analyses.

Variables with  $P < 0.2$  were considered for inclusion in a multivariable logistic regression model. The multivariable model was built using backward elimination; variables with  $P < 0.05$  were retained in the model, and the change in deviance was assessed to determine the best model fit. Due to missing data for some variables, the final multivariable model was based on data for 33 cases and 796 controls. Clustering within the dataset arising from some households owning >1 study cat was considered to be minimal, so was not accounted for due to very small group sizes and unbalanced data<sup>25</sup>. Out of the cases and controls (33 cats and 796 cats respectively) there were 144 single cat households and 650 multicat households (35 cats had missing data for the household type).

The sample size was determined by the number of questionnaires completed by 1<sup>st</sup> June 2015 and was estimated to have 80% power to detect odds ratios of 3.0 or more, based on a 95% level of confidence and assuming that 25% of controls were exposed to risk factors (Epi Info 2000 Online, available from <http://epitools.ausvet.com.au/content.php?page=CIProportion>).

IBM SPSS Statistics V.21 was used for data analysis.

The study was granted ethical approval by the University of Bristol's ethics committee (Reference: UIN/13/026). Owners gave fully informed consent for the use of their data and their data were used in accordance with the Data Protection Act.

## **Results**

The number of completed questionnaires available for analysis at the time of the study were as follows; 3m n=2172, 7m n=1900, 12 m n=1716, 18 m n=1586, 30 m n=1159 and 48 m n=248. Not all respondents completed all questions, resulting in additional missing data in each questionnaire. Figure 1 details how the numbers of cases and controls were determined.

Descriptive statistics

Of those cats seen urinating, a combination of owner-reported LUTS were observed, these are presented in table 2.

Table 2. The number and percentage of cats (seen urinating by their owners) with the signs used to define the outcome of owner-reported lower urinary tract signs (LUTS) in cats enrolled in the Bristol Cats Study at 18 m, 30 m and 48 m.

Owner-reported LUTS	18 m Number of cats (%)	30 m Number of cats (%)	48 m Number of cats (%)
Straining (S) only	1 (0.1)	1 (0.2)	1 (0.5)
Blood (B) only	7 (0.7)	1 (0.2)	0 (0)
Vocalising (V) only	27 (2.6)	15 (2.7)	7 (3.8)
V and S	1 (0.1)	0 (0)	1 (0.5)
V and B	0 (0)	0 (0)	0 (0)
S and B	1 (0.1)	2 (0.4)	0 (0)
V, S and B	7 (0.7)	2 (0.4)	2 (1.1)
No LUTS	986 (95.7)	536 (96.2)	171 (94.0)
Total number of cats seen urinating	1030	557	182

The prevalence estimates and 95% confidence intervals (CI) of owner-reported LUTS at 18 m, 30 m and 48 m are summarised in table 3; based on cats that were observed urinating by their owners and for all cats (including those whose owners had not seen them urinating).

Table 3. Prevalence estimates and 95% confidence intervals (CI) of owner-reported lower urinary tract signs (LUTS) at 18 m, 30 m and 48 m for cats enrolled in the Bristol Cats Study

Age	Number of cats with owner-reported LUTS	Number of cats observed urinating	Prevalence of LUTS for cats observed urinating (95% CI)	Number of cats (including those not seen urinating_	Prevalence of LUTS for all cats (including those not observed urinating) (95% CI)
18 m	44	1030	4.3% (3.2-5.7%)	1497	2.9% (2.2-3.9%)
30 m	21	557	3.8% (2.5-5.7%)	875	2.4% (1.6-3.6%)
48 m	11	182	6.0% (3.4-10.5%)	250	4.4% (2.5-7.7%)

Completion of all three questionnaires (questionnaires at ages 18 m, 30 m and 48 m) were completed by owners of 98 cats. Table 4 summarises owner-reported LUTS at the three time points for these 98 cats.

Table 4. The number (%) of cats that had one or more owner-reported lower urinary tract signs (LUTS) at 18, 30 and/or 48 m for the subsample of cats whose owners had completed questionnaires at 18 m, 30 m and 48 m for the Bristol Cats Study.

Time point/Age of cat	Number (%) of cats with owner-reported LUTS
18 m only	4 (4.1)
30 m only	0 (0)
48 m only	6 (6.1)
18 m and 30 m only	0 (0)
30 m and 48 m only	0 (0)
18 m, 30 m and 48 m	2 (2.0)
18 m and 48 m	0 (0)
No time points	86 (87.8)
Number of cats whose owners completed all 3 questionnaires (18 m, 30 m and 48 m)	98

The results of the univariable logistic regression analyses are summarised in table 5.

Six variables had P-values <0.2 and were thus carried forward to the multivariable

model building process (these are highlighted in bold in Table 5).

Table 5. Univariable logistic regression analysis of potential variables for owner-reported lower urinary tract signs (LUTS) at 18 m in a UK cat cohort.

Variable	Number of cases (Cats with owner-reported LUTS) (%)	Number of controls (Cats without owner- reported LUTS) (%)	P-value	Odds Ratio (95% CI)
<i>Sex</i>				
Male	25 (4.7)	503 (95.3)	0.39	1.0
Female	18 (3.6)	476 (96.4)		0.76 (0.41 to 1.41)
<i>Breed</i>				
DSH/DLH	27 (3.7)	701 (96.3)	0.20	1.0
Pedigree	15 (5.5)	256 (94.5)		1.52 (0.80 to 2.91)
<b><i>Diet at 12 m</i></b>				
<b>100% wet or mostly wet</b>	<b>14 (6.0)</b>	<b>221 (94.0)</b>	<b>0.06</b>	<b>1.0</b>
<b>All other diets</b>	<b>22 (3.2)</b>	<b>674 (96.8)</b>		<b>0.52 (0.26 to 1.02)</b>
<b><i>Diet at 18 m</i></b>				
<b>100% wet or mostly wet</b>	<b>19 (6.9)</b>	<b>255 (93.1)</b>	<b>0.02</b>	<b>1.0</b>
<b>All other diets</b>	<b>24 (3.4)</b>	<b>682 (96.6)</b>		<b>0.47 (0.25 to 0.88)</b>
<b><i>Change in diet between 12 m and 18 m</i></b>				
<b>No</b>	<b>18 (5.6)</b>	<b>303 (94.4)</b>	<b>0.06</b>	<b>1.0</b>
<b>Yes</b>	<b>17 (3.0)</b>	<b>556 (97.0)</b>		<b>1.94 (0.99 to 3.83)</b>
<i>Multi or single cat household at 12 m</i>				
Single cat	7 (4.1)	164 (95.9)	0.71	1.0
Multi-cat	26 (3.5)	718 (96.5)		0.85 (0.36 to 1.99)
<i>Multi or single cat household at 18 m</i>				
Single cat	7 (4.4)	153 (95.6)	0.57	1.0
Multi-cat	26 (3.4)	728 (96.6)		0.78 (0.33 to 1.83)
<i>Change in household type 'multi/single' cat</i>				



<i>household status between 12 m and 18 m</i>				
No	1 (4.5)	21 (95.5)		1.0
Yes	33 (3.7)	859 (96.3)	0.84	1.24 (0.16-9.50)
<b><i>Age of neutering up to 6 m</i></b>	<b>28 (3.6)</b>	<b>758 (96.4)</b>		<b>1.0</b>
<b><i>≥7 months</i></b>	<b>12 (7.7)</b>	<b>144 (92.3)</b>		<b>2.26 (1.12 to 4.54)</b>
<b><i>Entire at outcome</i></b>	<b>4 (6.6)</b>	<b>57 (93.4)</b>	<b>0.06</b>	<b>1.90 (0.64 to 5.60)</b>
<i>Number of cats in neighbourhood at 12 m</i>				
None	2 (2.7)	72 (97.3)		1.0
1-5	19 (3.2)	584 (96.8)		1.17 (0.27 to 5.13)
6-10	12 (5.1)	224 (94.9)		1.93 (0.42 to 8.82)
11 or more	3 (7.9)	35 (92.1)	0.31	3.09 (0.49 to 19.32)
<i>Number of cats in neighbourhood at 18 m</i>				
None	2 (2.7)	73 (97.3)		1.0
1-5	29 (4.5)	615 (95.5)		1.72 (0.40 to 7.36)
6-10	9 (3.6)	239 (96.4)		1.37 (0.29 to 6.51)
11 or more	4 (7.5)	49 (92.5)	0.55	2.98 (0.53 to 16.90)
<i>Visiting cats at 12 m</i>				
Yes	25 (4.1)	579 (95.9)		1.0
No	9 (3.8)	230 (96.2)	0.80	0.91 (0.42 to 1.97)
<i>Visiting cats at 18 m</i>				
Yes	25 (3.8)	641 (96.2)		1.0
No	5 (5.7)	83 (94.3)	0.39	1.55 (0.58 to 4.14)
<i>Reaction to the 'visiting' cats at 12 m</i>				
Positive	9 (3.4)	259 (96.6)		1.0
Negative	11 (4.8)	218 (95.2)		1.45 (0.59 to 3.57)
No reaction	4 (4.2)	92 (95.8)		1.25 (0.38 to 4.16)
Mixed reaction	6 (4.3)	134 (95.7)	0.88	1.29 (0.45 to 3.70)

<i>Reaction to the 'visiting' cats at 18 m</i>				
Positive	15 (5.4)	262 (94.6)		1.0
Negative	11 (3.8)	277 (96.2)		0.69 (0.31 to 1.54)
No reaction	4 (4.5)	85 (95.5)		0.82 (0.27 to 2.54)
Mixed reaction	5 (2.8)	171 (97.2)	0.59	0.51 (0.18 to 1.43)
<b><i>Indoor and outdoor lifestyle at 12 m</i></b>				
<b>100% indoors</b>	<b>15 (7.1)</b>	<b>195 (92.9)</b>		<b>1.0</b>
<b>Outdoor access</b>	<b>21 (2.8)</b>	<b>726 (97.2)</b>	<b>0.005</b>	<b>0.38 (0.19 to 0.74)</b>
<b><i>Indoor and outdoor lifestyle at 18 m</i></b>				
<b>100% indoors</b>	<b>18 (7.9)</b>	<b>211 (92.1)</b>		<b>1.0</b>
<b>Outdoor access</b>	<b>26 (3.3)</b>	<b>773 (96.7)</b>	<b>0.003</b>	<b>0.39 (0.21 to 0.73)</b>
<i>Change in indoor and outdoor lifestyle between 12 m and 18 m</i>				
No	3 (2.3)	129 (97.7)		1.0
Yes	33 (4.0)	790 (96.0)	0.34	0.56 (0.17 to 1.84)
<i>Moved house In past year at 18 m</i>				
Yes	6 (6.5)	86 (93.5)		1.0
No	38 (4.1)	891 (95.9)	0.28	0.61 (0.25 TO 1.49)
<i>Body condition score at 18 m</i>				
1, 2 or 3	38 (4.4)	830 (95.6)		1.0
4 or 5	5 (3.8)	125 (96.2)	0.78	0.87 (0.34 to 2.26)
<i>Interaction with other cats in household at 18 m</i>				

Positive reaction	1 (1.4)	70 (98.6)		1.0
Negative reaction	2 (6.7)	28 (93.3)		5.0 (0.44 to 57.37)
No or mixed reaction	29 (3.9)	712 (96.1)	0.43	2.85 (0.38 to 21.25)
<i>Been in fight past 6 m at 18 m</i>				
Yes	4 (2.4)	160 (97.6)		1.0
No	12 (3.2)	362 (96.8)	0.63	1.33 (0.42 to 4.17)

Variables in bold indicate those with  $P < 0.2$  which were considered for inclusion in the final multivariable model.

The final multivariable model, built using the six variables with a P-value  $< 0.2$ , is

summarised in Table 6.

Table 6. The final multivariable logistic regression model for variables associated with owner-reported lower urinary tract signs (LUTS) at 18 m in a UK cat cohort.

Variable	Number (%) of cases (Cats with owner- reported LUTS)	Number (%) of controls (Cats without owner- reported LUTS)	P-value	OR (95% confidence intervals)
Indoor and outdoor lifestyle at 18 m				
Outdoor access	19 (2.9)	644 (97.1)		1.00
Indoor only	14 (8.4)	152 (91.6)	0.003	3.01 (1.47-6.17)
Change in diet between 12 m and 18 m				
No	15 (2.8)	520 (97.2)		1.00
Yes	18 (6.1)	276 (93.9)	0.032	2.17 (1.07 to 4.39)

From the multivariable model, an indoor only lifestyle and a change in diet between 12 m and 18 m were identified as risk factors for owner-reported LUTS at 18 m. No clear type of change in diet was identified in our sample of case cats (Table 7).

Table 7. Change of diet category and the number of cases who had a diet change between 12 m and 18 m

Diet category change	Number of cases which changed diet type
50:50 to mostly wet	5
Mostly wet to 50:50	3
Mostly dry to 100% dry	2
100% dry to mostly dry	2
Mostly dry to 50:50	1
Fresh to mostly dry	1
50:50 to mostly dry	1
Fresh to 50:50	1
Mostly dry to mostly wet	1
Mostly wet to mostly dry	1
Total number of cases which had a diet change between 12 m and 18 m	18

## Discussion

The most important findings of this study were that the prevalence of owner-reported LUTS was higher than that previously reported for cats presenting to veterinary hospitals for LUTS or other reasons, and that a change in diet between 12 and 18 m of age and an indoor only lifestyle at 18 m are risk factors for LUTS.

LUTS represent a common clinical problem in cats. To date, the majority of published studies of FIC were based on data collected from cats that had visited a veterinary

practice because of their LUTS. It is unlikely that all cats displaying LUTS recognised by their owner are presented to a vet on the first instance of these signs. It is possible that the signs become more severe, or unacceptable to the owner (such as periuria) before these cats are presented to a vet, hence the true prevalence of LUTS might be higher than reported in the literature and may occur at a younger age. LUTS can be linked to disease and be observed in healthy cats, so without a complete diagnostic investigation we cannot say whether the cats that showed LUTS in our study had FIC, if the signs were due to another cause, or if they occurred in a healthy cat exposed to unusually threatening conditions<sup>26</sup>.

We found a prevalence of owner-reported LUTS of 4.5% at 18 m, 3.9% at 30 m and 6.4% at 48 m, which are higher than veterinary-reported data<sup>10,11</sup>. However, it must be noted that the veterinary reported prevalence cannot be directly compared to the owner reported prevalence, as the cases in the owner reported prevalence study have not had a confirmed diagnosis of lower urinary tract disease, like the veterinary reported prevalence data did. We propose two reasons why this might be the case. Firstly, the data in this study were based on owner-reported LUTS, whereas previously published prevalence estimates were based on data obtained from cats that had been presented to a veterinarian for LUTS. Assessing the prevalence of LUTS when including all study

cats (i.e., those seen and not seen urinating) the prevalence was 2.9% at 18 m 2.4% at 30 m and 4.4% at 48 m. These lower numbers may be more accurate because they were less susceptible to bias arising from only including those cats seen urinating, which may have falsely increased the prevalence of owner-reported LUTS if cats with LUTS were more likely to have been seen urinating than cats without LUTS. This is because of the nature of LUTS; cats that pass urine more frequently, vocalise when urinating and urinate in inappropriate places in the house are more noticeable to their owner.

There are limitations to this study to be taken into account when interpreting the prevalence of owner-reported LUTS in this cohort of cats. We may have had a higher prevalence for LUTS than is true of the general population of cats within the UK for a number of reasons. Firstly, by the nature of a long-term longitudinal study, the cohort consists of cats owned by highly motivated owners, who might be more likely to notice (and thus report) LUTS, in comparison to a randomly selected population of cat owners. However, it could also be argued that such owners might provide a more accurate report of disease than less motivated owners who might miss signs of disease. As the LUTS were owner-reported, we cannot confirm that these cats actually had lower urinary tract disease. Some clinical records for cats are potentially accessible, but this relies on the owner having taken the cat to a veterinarian because of the LUTS in the first instance,

which we suspect is not always the case. It must be noted that the owner-reported LUTS 'haematuria' was not confirmed by urinalysis, therefore haemoglobinuria or myoglobinuria cannot be excluded in these cases, which are not necessarily linked to FIC. Our case definition included cats that, for example, might have had just one episode of vocalising whilst urinating which potentially led to some misclassification of controls as cases.

Vocalising when urinating was the single most commonly reported LUTS (Table 2) and represented 61-71% of all cats with owner-reported LUTS. However, it should be noted that the owner-reported sign of 'vocalising before or during urination' may not be a direct indicator of LUTS. If cats were vocalising for other reasons then our prevalence estimates will have been over-estimated; however, anecdotal reports and personal experience of the authors suggests that vocalisation before/during urination is a commonly used owner-reported sign of LUTS used by veterinarians in practice. LUTS reported by owners at different times suggested that the signs were intermittent rather than persistent, and only two cats had LUTS at all three questionnaire times (Table 4). It is likely that if LUTS are intermittent and mild, then cats may not be presented to a vet. Although we did not collect data on the severity of LUTS, it could be speculated that



the prevalence of LUTS in the general cat population is higher than suggested by data collected from veterinary practices.

*Risk factors for owner-reported LUTS at 18 m*

Results of the multivariable logistic regression analysis indicated that an indoor only lifestyle and a change in diet between 12 m and 18 m were both significantly associated with an increased risk of owner-reported LUTS at 18 m (Table 6). The finding of a change in diet between 12 m and 18 m being significantly associated with an increased risk of owner-reported LUTS is interesting. As indicated in table 7, there was no apparent pattern to the type of change in diet that was associated with this increased risk. A change in diet could be a proxy for another event, for example if another cat in the household was ill and the owner was advised to feed a different diet, then all cats in the house may have changed diets because of this. Another possibility is that the cat was showing LUTS and the owner changed the diet because of this, so the change in diet was a consequence of LUTS, rather than a cause. It could be speculated that the change in diet itself may not have been the stressor, but an event such as a cat being unwell in the household could cause stress and hence LUTS. The type of diet was not retained in our multivariable model, yet a change in diet was, suggesting that it was the change in diet, rather than the diet itself that increased the risk for owner-reported LUTS. Only 18 cats

had owner-reported LUTS and also had a change in diet, which represents a relatively small sample size. A larger sample size might provide more information on change in diet and how it affects owner-reported LUTS, and is an area where we recommend further research. A previous study reported that a diet high in dry food was associated with an increased risk of LUTS<sup>8</sup>. In this study the categories of 100% dry, mostly dry, 50:50, true mix and fresh food were grouped together as the univariable stage of analysis did not identify a link between a dry diet (100% dry, or mostly dry combined) and owner-reported LUTS as compared to any other category.

In contrast to previous research, where cats in multicat households, cats with conflict between cats living in the same household, cats with high body condition score, male cats and pedigree cats were reported to be more likely to have FIC<sup>1,8</sup>, we found no evidence of a significant association between these factors and owner-reported LUTS at 18 m of age (table 5). Reasons for this contrast in findings between our study and previously published studies could be because the LUTS used for our case and control definitions were owner-reported only, whereas the studies mentioned<sup>1,8</sup> used cats previously diagnosed with LUTS or cats presented to veterinary practices because of their LUTS. The limited statistical power of our study may also account for the discrepancy between our results and veterinary published data. We did not find any

significant evidence of association with neuter status between cases and controls, which is in agreement with other work<sup>27</sup>.

## **Conclusions**

In conclusion, the prevalence of owner-reported LUTS within this UK cat cohort was estimated to be at least 2.9% (95%CI 2.2-3.9%) at 18 m, 2.4% (95%CI 1.6-3.6%) at 30m and 4.4% (95%CI 2.5-7.7%) at 48 m. We have also demonstrated evidence of an association between both a change in the diet between 12 m and 18 m, and an indoor only lifestyle, with owner-reported LUTS. We did not demonstrate a significant association between the more commonly reported risk factors of higher body condition score, eating a dry diet, neuter status, breed or sex with owner-reported LUTS.

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## Conflict of interest statements

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